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19. ABSTRACT (Continue on reverse if necessary and identify by block number)
TOP 7-3-523 describes general procedures for technical testing of infrared suppression devices under conditions typical of those for which they were designed. Ground and airborne infrared detection systems will be used to determine the capability of the suppression device to perform its intended purpose. Procedures include: inspection, installation, technical performance, effects of environmental conditions, logistic supportability, reliability, achieved availability, compatibility, safety, human factors, and personnel and training requirements. Data requirements and presentation are also described.

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U.S. ARMY TEST AND EVALUATION COMMAND
TEST OPERATIONS PROCEDURE

AMSTE-RP 702-106
*Test Operations Procedure (TOP) 7-3-523 13 April 1990
AD No.

AIRCRAFT INFRARED SUPPRESSION DEVICES

1. SCOPE.

a. This TOP describes procedures for testing infrared suppression devices under conditions typical of those for which they were designed. Ground and airborne infrared detection systems will be used to determine the capability of the suppression device to perform its intended purpose.

* This TOP supersedes MTP 7-3-523 dated 1 September 1971.
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b. The procedures specified apply to technical testing of infrared suppression devices. Since usage and design of these devices may cover a wide range, the procedures have been presented in a general manner. The use of particular procedures will be determined by specific applications and locations. Pertinent, applicable requirements will be used to derive test criteria and to formulate test conditions.

2. FACILITIES AND INSTRUMENTATION.

2.1 Facilities. Testing should normally be conducted from fixed-base airfields due to the sensitivity of equipment used to monitor, record, and analyze data.

2.1.1 Maintenance Area. Maintenance areas should be of sufficient size and configuration to allow for parking, inspection, and limited repair of the test-bed airframe. An area for unpacking, inspection, and installation of the test item and data collection equipment should be identified. Bench test facilities with power supplies should be available.

2.1.2 Ground Run/Test Flight Areas. Ground run areas should normally be level, hard-surfaced, and close to instrumentation areas. Test flight areas should allow for operation under established flight profiles. Exclude extreme heat, cold, or high altitude areas unless such conditions are a specific test consideration.

2.1.3 Maintenance Personnel, Tools, and Test Equipment. The complexity of the test-bed aircraft, test item(s), and data collection equipment will dictate the number and skill level of personnel selected to support the test. Select tools and test equipment under the same criteria. If military personnel of the appropriate MOS are not available, consider contractor's or manufacturer's support.

3. REQUIRED TEST CONDITIONS.

3.1 Support.

a. Select and schedule suitable operational areas at representative locations. Ensure availability of maintenance support facilities, special test equipment, repair parts, and personnel.

b. Ensure that all required support aircraft have been scheduled.

c. Obtain applicable frequency assignments, if required, before operating the test item and support equipment.

d. Coordinate with supporting and participating agencies, activities, and facilities.

3.2 Personnel.

a. Ensure that personnel with appropriate MOS and skill levels for operation and maintenance of the test item are properly trained.

b. Conduct additional training in the following areas:

(1) Procedures to be followed and data to be collected during the test.

(2) Hazards and safety precautions associated with the test item, test procedures, and test equipment.

c. If personnel are non-exempt troops IAW TECOM Suppl to AR 70-25[1], ensure that the test plan has been reviewed and approved by the HQ TECOM Human Use Committee.

4. TEST PROCEDURES. The following subtests are arranged in a logical sequence to provide a step-by-step analysis of the suitability of infrared suppression devices to perform their primary function of suppressing or masking infrared emissions from aircraft.

4.1 Inspection. This subtest will establish condition and completeness of the test item and associated equipment.

4.1.1 Inventory Check and Inspection.

a. Method.

(1) Inventory test item against the Basic Issue Item List (BIIL).

(2) Inspect test item. Inspection points should include:

(a) Removal of all preservatives.

(b) Inspection for obvious defects.

(c) Completeness of assembly.

(d) Completeness of maintenance package and verification against any included packing list.

(e) Verification of any required lubrication.

(3) Inspect test item for safety hazards using a tailored safety and health checklist. Use checklists in TOP 6-2-507[2] and 7-3-506[3], as appropriate, as guides.

[1]Reference numbers match those in Appendix B, References.

(4) Complete a Test Incident Report (TIR) for all observed shortages or discrepancies (AMC Reg 70-13).[4]

b. Data Required. Record the following:

(1) Physical defects of the test item and any shipping containers.

(2) Completeness of the BIIL.

(3) Completeness of the assembly.

(4) Completeness of the maintenance package.

4.1.2 Physical Characteristics. (MTP 7-3-500)[5]

a. Method.

(1) Note legibility, effectiveness, and correctness of markings, legends, etc.

(2) Determine dimensions, weight, and volume (if applicable) of all test item components.

(3) Compute the test item's total weight and volume.

(4) Photograph all test item components before and after installation.

b. Data Required. Record the following:

(1) Equipment markings.

(2) Dimensions, weight, and volume of all components of the test item and the total system weight and volume.

4.1.3 Technical Characteristics.

a. Method. Examine the following technical properties (as applicable):

(1) Controls, adjustments, and indicators - Determine the following as appropriate:

(a) Operation.

(b) Effect on the system.

(c) Adequacy of movement.

(d) Proper calibration.

(e) Changes are monitored and displayed correctly.

(f) Range and sensitivity.

Evaluations requiring flight will be conducted during the Technical Performance subtest.

(2) Equipment safety and protective devices - Determine adequacy.

(3) Fail-safe characteristics - When the system becomes inoperative because of failure, operator personnel will be made aware of the condition. When possible, simulate failures and determine suitability of all fail-safe features.

(4) Confidence, self-checking, or integrity circuits, if any - Verify proper operation.

(5) Cold-start and warmup - Subject the system to the required number of cold-start power application procedures. Determine warmup and effects due to multiple power-up applications.

b. Data Required. Record the following:

(1) Controls and indicators.

(a) Improper operation.

(b) Calibration.

(c) Monitoring and display of system conditions.

(2) Operation of safety devices.

(3) Operation of fail-safe features.

(4) Operation of self-checking features.

(5) Warmup time.

4.2 Installation Characteristics. This subtest will determine installation requirements, including placement and removal procedures, stability of mountings, and flexibility for use on various aircraft.

a. Method.

(1) Determine installation requirements (time, effort, tools, materials, personnel, instructions, etc.)

(2) Ensure that the test item is secure, protected against shock and vibration, and mechanically stable.

(3) Determine mounting requirements for installation on various types of aircraft.

(4) Photograph pertinent installation procedures.

b. Data Required. Record the following:

(1) Time required.

(2) Tools required.

(3) Ease of installation and removal.

(4) Equipment flexibility for arrangement and mounting.

(5) Accessibility for maintenance.

(6) Common (interchangeable) fittings and connections.

4.3 Technical Performance. This subtest will determine performance characteristics of the test item.

4.3.1 Technical Performance Against Ground Detection.

a. Method.

(1) Establish a ground station equipped with applicable ground-to-air infrared detector equipment.

(2) Fly aircraft in appropriate flight patterns relative to the ground station. Prepare flight plans on map overlays showing length and direction of data tracks, altitudes, and ground reference points. Use varying directions of arrival, hover in-ground-effect (HIGE), hover out-of-ground-effect (HOGE), and forward flight to velocity-not-to-exceed (Vne) conditions.

(3) Measure/record ranges and IR signatures detected for each condition of flight performed with the test item unpowered or not installed (baseline) and with the test item in all operating modes.

(4) Compare range and baseline signature data with that obtained for each measured flight condition and determine the effectiveness of the test item against ground detection equipment.

b. Data Required. Record the following:

(1) Surveyed locations of ground station and reference points.

(2) Start and elapsed time of each trial.

(3) Altitude, airspeed, and range at which infrared signatures are detected with the test item unpowered.

(4) Altitude, airspeed, and range at which infrared signatures are detected with the test item operating.

(5) Comments on effectiveness of the test item.

(6) A block diagram showing the setup for each specified test. The block diagram shall identify, by model, all test equipment and interconnections.

(7) Photographs, video, charts, graphs, or other records which support test analysis and findings.

(8) Meteorological data and other pertinent environmental observations.

(9) Test parameters, theoretical estimations, and mathematical calculations used in the analysis of test data.

4.3.2 Technical Performance Against Airborne Detection.

a. Method.

(1) Fly a test-item-equipped-aircraft on both parallel and nonparallel courses with an aircraft equipped with an infrared signature measuring device.

(2) Parallel flight profiles should be:

(a) In opposite directions.

(b) In the same direction with the detection-device-equipped aircraft overtaking the test-item-equipped aircraft.

(3) Since the IR signature of the aircraft and the IR suppression capabilities of the suppressor are not the same from all aspect angles, fly nonparallel flight profiles to document 360^{o} suppression capabilities.

(4) Perform flights during both daylight and darkness with the test-item-equipped aircraft flying at both optimum and maximum airspeeds.

(5) Recommended minimum aircraft separations are:

(a) Detector-equipped aircraft 1,000 feet above test-item-equipped aircraft (500 feet in daylight).

(b) Detector-equipped aircraft 1,000 feet below test-item-equipped aircraft (500 feet in daylight).

(c) Detector equipped aircraft 1,000 feet right and left of test-item-equipped aircraft (500 feet in daylight).

(6) Measure ranges and signature data with the test item both unpowered and operating.

(7) Compare range and pattern graphs for each different flight condition and determine the effectiveness of the test item against airborne detection equipment.

b. Data Required.

(1) Start and elapsed time of each operation.

(2) Aircraft separation distance, altitude, airspeed, range, and signature data with the test item unpowered.

(3) Aircraft separation distance, altitude, airspeed, range, and signature data with the test item operating.

(4) Comments on effectiveness of the test item.

(5) A block diagram showing the setup for each specified test. The block diagram shall identify, by model, all test equipment and interconnections.

(6) Photographs, video, charts, graphs, or other records which support test analysis and findings.

(7) Meteorological data and other pertinent environmental observations.

(8) Test parameters, theoretical estimations, and mathematical calculations used in the analysis of test data.

4.4 Effects of Environmental Conditions. This subtest will determine capabilities and limitations imposed upon operation of the test item due to existing environmental conditions.

4.4.1 Method.

a. Conduct tests day and night over various types of geographic surfaces. Consider the following:

(1) Water/land interfaces.

(2) Isolated bodies of water.

(3) Mountain ranges.

(4) Areas with varying types and degrees of vegetation.

(5) Snow-covered ground, desert, etc. (look at extremes).

b. Repeat selected tests during periods when changes in atmospheric conditions exist. Include the following conditions:

(1) Sunrise and sunset.

(2) Daytime and nighttime hours.

(3) Rain, fog, snow, and clouds.

(4) High and low temperatures.

4.4.2 Data Required. Record the following:

a. Details of the geographic surface at time of data collection.

b. Changes in quality of suppression.

c. Comments regarding effectiveness of the test item and any problems experienced.

d. Details of atmospheric conditions at the time of data collection.

e. Changes in infrared signature.

4.5 Logistic Supportability. Testing will normally be conducted simultaneously and in conjunction with other test operations. Separate, independent test functions, real or simulated, will be performed as required to ensure a complete exercise of all the logistic supportability aspects of the test system. The scope of the logistic supportability testing will encompass all subelements listed below. Testing must be consistent with the availability of required support elements and maturity of the test hardware. These data should be delineated in the test planning/execution directive.

- End item requirement
- Supply support
- Technical data/equipment publications
- Support and test equipment
- Manpower and personnel, training, and training devices
- Transportation and handling
- Facilities

These basic subelements may be further subdivided to enhance the clarity and understanding of an individual subtest. Subelement breakouts/divisions are usually dependent upon the maturity and complexity of the test system and test constraints (time, dollars) placed on the test effort. Specific criteria for each subelement must be extracted from program documentation (requirements,

specification, acquisition, etc.). A brief explanation of each logistic supportability test subelement listed above and specific guidance to conduct each subelement are contained in TOP 7-3-507[6].

4.6 Reliability. This subtest will determine reliability of the test item in terms of failure-free operation time and mean-time-between-failure (MTBF) (TOP 7-3-508[7]).

a. Method.

(1) Maintain a complete log of all assembly, installation, operation, disassembly, and maintenance performed on the test item.

(2) Record data on Supportability Analysis Charts (SAC's) as described in TOP 7-3-507.

(3) Calculate MTBF of the test item, using appropriate procedures in TOP 7-3-508.

b. Data Required. Record the following:

(1) Hours of operation, daily and cumulative.

(2) Equipment failures and malfunctions, including chronological data required to determine failure-free operating time and MTBF.

(3) Completed SAC's.

(4) Effect of failures on the test conduct.

4.7 Achieved Availability. This subtest will determine the probability that the test item, when used under stated conditions in an ideal support environment, will operate satisfactorily at any given time (TOP 7-3-507).

a. Method.

(1) Calculate the Operating Time (OT) of the test item.

(2) Calculate the Preventive Maintenance Time (PMT) devoted to the test item.

(3) Calculate the Corrective Maintenance Time (CMT) devoted to the test item.

(4) Calculate the Achieved Availability (Aa) of the test item using the following formula:

$$Aa = \frac{OT}{OT + PMT + CMT}$$

b. Data Required. Use the data previously collected on maintainability, reliability, and operating time.

4.8 Compatibility. This subtest will determine effects and interactions of the test item with the established configuration of the test-bed aircraft (TOP 7-3-509[8]).

a. Method. Note any instances of incompatibility using the following as a guide:

(1) Preparation for Use - Note the need, during installation, for special tools, hardware, mounting brackets, etc., and nonstandard size or overweight items.

(2) Operation and Performance - Note, during the operational procedures, whether the test item interferes with, or is interfered by, other onboard or ground-based electronic systems (EMI/EMC testing). This can be accomplished by operating the test item simultaneously with other onboard electrical systems and in the presence of various types of radio frequency fields generated by ground installations. Compatibility of the test item with other onboard electronic and mechanical systems will be determined.

b. Data Required. Record the following:

(1) Physical or electrical characteristics not compatible with system capabilities.

(2) Instances when the test item interferes with or is interfered by other equipment generating, using, or radiating electrical energy.

(3) Test item compatibility with existing electronic equipment.

4.9 Safety. This subtest will determine hazardous characteristics of the design and operating procedures of the test item. (TECOM Supplement 1 to AR 385-16[9], TOP 7-3-506)

a. Method.

(1) Observe proper safety precautions and adhere closely to any manual's directives which deal with safety and/or protection.

(2) Examine the procedures for all tests. Report any hazard to project personnel.

(3) Examine the characteristics of the test item including procedures for its operation and maintenance to ensure that maximum safety has been provided. Consider the following:

(a) Review airworthiness/safety releases required for flight.

(b) Examine operating procedures with a view that improperly executed or misinterpreted instructions could result in bodily harm or equipment damage.

(c) When hazardous conditions cannot be avoided, is the item properly and conspicuously marked for the conditions?

(d) Are all moving parts shielded and completely enclosed?

(e) When electrical power is used, are the electrical circuits guarded against accidental contact?

(f) Are environmental limitations explicitly denoted?

(4) Determine the adequacy of all protective and warning devices. Consider the following:

(a) Overheat devices.

(b) Overload protection.

(c) Locking mechanisms.

(d) Limit switches.

(e) Visual and audible warning devices.

(f) Interlocks.

b. Data Required. Record the following:

(1) Comments regarding hazardous conditions found during the conduct of any test.

(2) For general safety characteristics:

(a) Poorly worded or unclear operating instructions.

(b) Warning labels - lacking or not conspicuous.

(c) Unprotected electrical circuits.

(d) Markings or environmental limitation missing.

(3) Prepare a table to include the following:

(a) A list of all safety devices used.

(b) The type of failure each device is to detect.

(c) Indication that the device has successfully operated.

(4) List any missing devices or unsafe conditions.

(5) List any suggested additions to the safety features.

(6) Prepare a safety confirmation statement.

4.10 Human Factors. This subtest will evaluate the degree to which the test item conforms to acceptable human engineering design criteria as outlined in MIL-STD-1472D[10] and MIL-HDBK-759A[11].

a. Method. The human factors characteristics of the system will be assessed using task and design characteristics checklists developed IAW TOP 1-2-610[12]. The purpose of the checklist is to rate, from a human factors standpoint, the tasks associated with, and the characteristics revealed during the procedures for preparing, operating, transporting, and maintaining the test item. The rating will be either satisfactory or unsatisfactory with explanatory information accompanying an unsatisfactory rating. Subjective data from personnel performing operation/maintainer tasks outlined in the instruction/technical manuals will be collected using questionnaires developed and administered in accordance with TECOM Pam 602-1[13]. Questionnaire data would be used in the following paragraphs: 4.3.1.b(5), 4.3.2.b(4), 4.4.2.c, 4.9.b(1), 4.9.b(5), 4.11.b(2), and 4.11.b(3).

(1) For all tasks/characteristics the following will be considered:

(a) Ease of performance - Mental and physical effort required.

(b) Support - Adequacy of instructions and tools for the task.

(c) Time required - Modification of procedures to reduce time required.

(d) Design characteristics - Effects on performance of tasks.

(2) Rate the following tasks/characteristics for the evaluation listed.

(a) Preparation for Use.

Assemble components, move to installation location, place in position, make external connections, and lock into position with fasteners, connectors, etc.

Apply power, check controls and indicators.

Make required alignment, calibrate, and adjust.

(b) Operation and Performance.

Operate controls, note changes in equipment status, monitor other displays.

Evaluate interface between the test item controls and indicators and the aircraft controls and indicators.

Note legends, their effectiveness, readability, and visibility.

Note performance, operation, and system status feedback to operator (auditory, visual, etc.).

Night operation - adequacy of the test item's control and indicator lights and interface with cockpit lighting scheme.

(c) Maintenance.

Perform preventive maintenance:

Clean, add lubricants.

Remove and replace minor items.

Tighten fasteners, connectors.

Adjust, calibrate, align.

Perform unscheduled maintenance:

Detect malfunction by observing displays, noting visual or audible changes, or changes in operating effectiveness.

Isolate and identify malfunction causes by visual means or instrumentation.

Open, gain access to, and remove component.

Replace or repair and re-establish proper operation.

b. Data Required. Record instances of the following:

(1) Instructions.

(a) Lacking clarity.

(b) Insufficient or excessive detail.

(2) Tools.

(a) Proper tools not supplied.

(b) Excess of special tools specified.

(c) Additional tools recommended.

(3) Mental and Physical Effort.

(a) Above average skill or strength required.

(b) Task is excessively tiring.

(4) Design.

(a) Poor location of component.

(b) Component not accessible.

(c) Visibility hindered.

(d) Adequacy of controls, adjustment, etc.

(5) Time required for task (if excessive, reason why).

(6) Personnel requirements.

(a) Insufficient number specified.

(b) Qualifications in error.

4.11 Personnel and Training Requirements. This subtest will determine adequacy and sufficiency of training and appropriateness of skill levels and experience required to operate and maintain the test item.

a. Method.

(1) Employ personnel of varying skill levels and experience throughout the test program to determine skill level requirements.

(2) Review performance of personnel during operational and maintenance procedures, paying particular attention to mistakes or errors made in operational procedures and excessively long maintenance tasks.

(3) Review the effects of training programs as to their adequacy, etc., noting also any additional training required during the test and suggestions for changes in the training program.

(4) Make a quantitative estimate of the average number of training hours required for both operational and maintenance personnel.

b. Data Requirements. Record the following:

(1) The most appropriate skill levels and experience (background) suggested for operator and maintenance personnel.

(2) Any suggested changes of training techniques, literature, etc., to eliminate operator errors or reduce maintenance time.

(3) Each additional training technique used after the start of testing and suggestions for additions or deletions to the training program.

(4) The training time required for maintenance and operator personnel.

5. DATA REQUIRED.

5.1 Preparation for Test. Data to be recorded before testing will include, as a minimum, the following:

a. Test item nomenclature, serial number(s), and other pertinent data.

b. Test equipment nomenclature, serial number(s), functional description, accuracy tolerances, calibration requirements, and date of last calibration.

5.2 Test Conduct.

a. Refer to paragraph 4, Test Procedures, for specific data requirements for individual subtests.

b. Data originating in all tests and subtests will be recorded as appropriate:

(1) Operators', observers', and test controllers' records and questionnaires.

(2) Narrative comments and observations.

(3) Maintenance records.

(4) Photographs.

(5) Diagrams and sketches.

c. All data will be properly identified and annotated with respect to:

(1) Test/subtest.

(2) Source.

(3) Date/time.

(4) Pertinent information.

d. Data to be recorded in addition to specific instructions given in preceding paragraphs will include:

(1) Sample size (number of measurement repetitions).

(2) Instrument or measurement system mean accuracy tolerances.

6. PRESENTATION OF DATA. Test findings will consist of the following:

a. Composite documentation of the reduced and correlated data arranged by subtest in the general form of narrative description supported by diagrams, photographs, graphs, and tabular data.

b. An analysis to determine the extent to which the test item reduced the vulnerability of the aircraft to enemy detection and attack by suppressing or masking the inherent infrared emissions of the aircraft.

c. Supplements or annexes to the basic report, delineating the common test factors which are of sufficient scope, importance, and/or complexity to warrant separate treatment. Each supplement will include the applicable supporting data.

d. A further analysis to determine the extent to which the test item exceeds the performance characteristics or otherwise provides distinct advantages over existing Army equipment providing the same functions.

e. Equipment evaluation will be limited to comparing the actual test results to the equipment specifications imposed by the intended usage.

Forward comments, recommended changes, or any pertinent data which may be of use in improving this publication to Commander, U.S. Army Test and Evaluation Command, ATTN: AMSTE-TC-M, Aberdeen Proving Ground, MD 21005-5055. Technical information may be obtained from the preparing activity: Commander, U.S. Army Aviation Development Test Activity, ATTN: STEBG-MP-P, Fort Rucker, AL 36362-5276. Additional copies are available from the Defense Technical Information Center, Cameron Station, Alexandria, VA 22304-6145. This document is identified by the accession number (AD No.) printed on the first page.

APPENDIX A. BACKGROUND

Infrared radiation is photon energy, or radiation that is emitted by every substance above a temperature of absolute zero (-459.67° F). The larger the object and the higher its temperature, the greater the energy emitted. The infrared region of the electromagnetic spectrum falls between the visible light and the microwave sections of the spectrum, covering the wavelengths ranging from 0.75 microns to 1000 microns. Heat sources radiate infrared energy nonuniformly over a wide wavelength range. Aircraft engine exhaust and exposed metal surfaces heated by the aircraft engines emit considerable infrared radiation. This emission makes the aircraft vulnerable, day or night, to detection by enemy airborne or ground-based infrared detectors and subsequent attack by enemy air-to-air or surface-to-air heat seeking missiles and conventional firepower. To reduce this vulnerability, infrared suppression devices have been designed and developed to suppress or mask the inherent infrared emissions of the aircraft. Such devices must be tested to determine their effectiveness and suitability for Army use.

APPENDIX B. REFERENCES

Required References

1. AR 70-25, Use of Volunteeers as Subject of Research, 8 Aug 88.

2. TOP 6-2-507, Safety and Health Hazard Evaluation - Communication/ Electronic Equipment, 15 Jun 81.

3. TOP 7-3-506, Safety (Aviation Materiel), 18 Jan 82.

4. AMC Reg 70-13, Test Incident and Related Reporting, 27 Jul 88.

5. TOP 7-3-500, Physical Characteristics, 27 Nov 77.

6. TOP 7-3-507, Integrated Logistics Supportability (Aviation Materiel), 1 Sep 83.

7. TOP 7-3-508, Reliability (Aviation Materiel), 26 Jul 77.

8. TOP 7-3-509, Compatibility, Related Equipment, (Aviation Materiel), 15 May 78.

9. TECOM Supplement 1 to AR 385-16, Safety: Safety for Systems, Associated Subsystems, and Equipment, 11 Jun 62.

10. MIL-STD-1472D, Human Engineering Design Criteria for Military Systems, Equipment and Facilities, 14 Mar 89.

11. MIL-HDBK-759A(MI), Human Factors Engineering Design for Army Materiel, 30 Jun 81.

12. TOP 1-2-610, Human Factors Engineering, 30 Nov 83.

13. TECOM Pam 602-1, Vol 1, Questionnaire and Interview Design, 25 Jul 75.